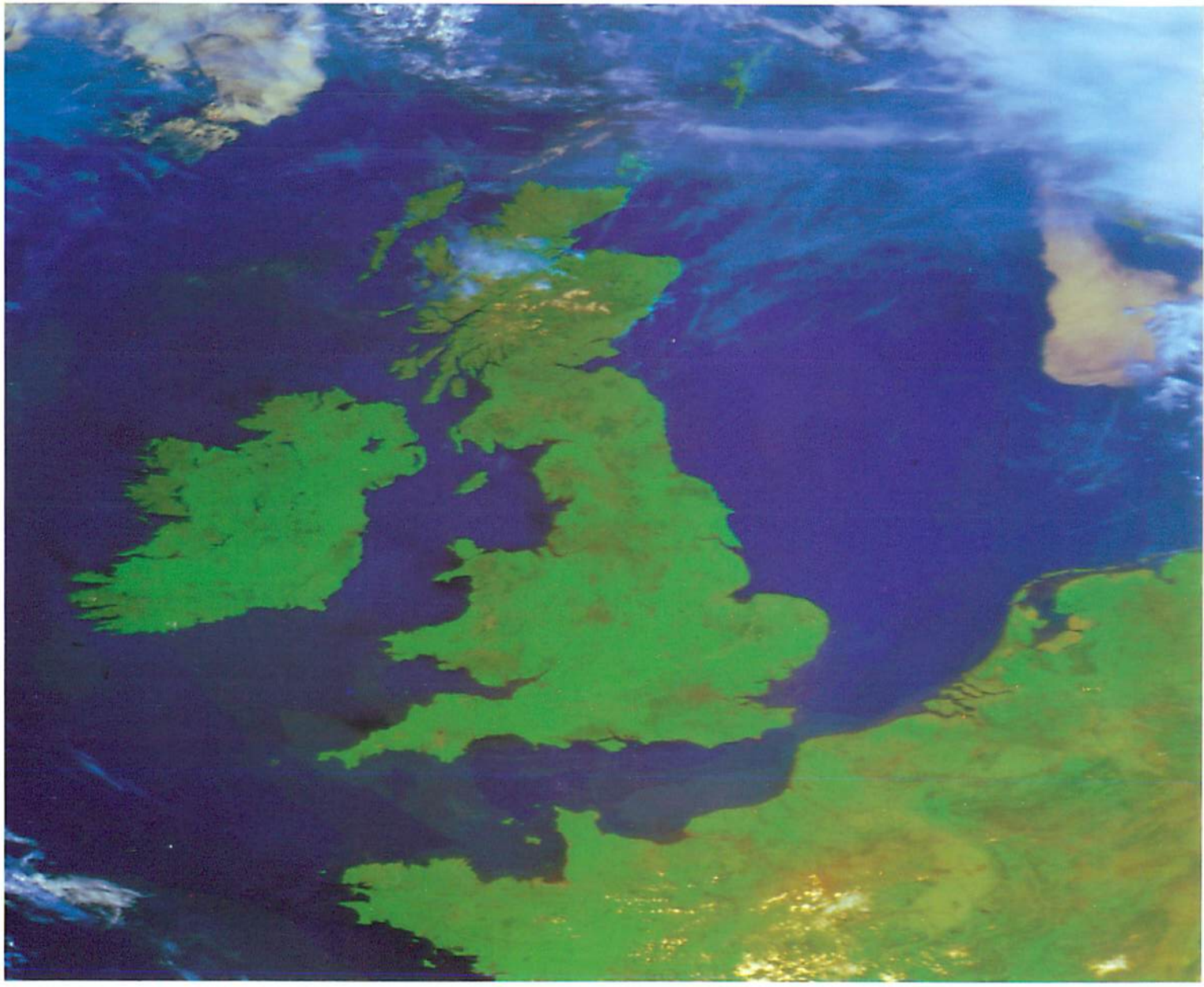
BRITAIN IN SPACE



BNSC

rep.00103

The BNSC

The British National Space Centre (BNSC) was formed at the end of 1985. It is a partnership which brings together the civil space interests of the Department of Trade and Industry, the Ministry of Defence, the Science and Engineering Research Council and the Natural Environment Research Council. Responsibility for funding rests with the constituent Departments and Councils according to their particular responsibilities, but the Centre provides coherence and added value because of the links which it can create between programmes and interests.

The Centre's role is to carry through the programmes and projects on which the Government has embarked, and to advise the Government on new space programme proposals and opportunities as they arise. The main task of the Director General, who reports to the Secretary of State for Trade and Industry, is the co-ordination of UK civil space policy to secure, by the cost effective use of resources, the maximum scientific, technological and commercial benefit to the UK.

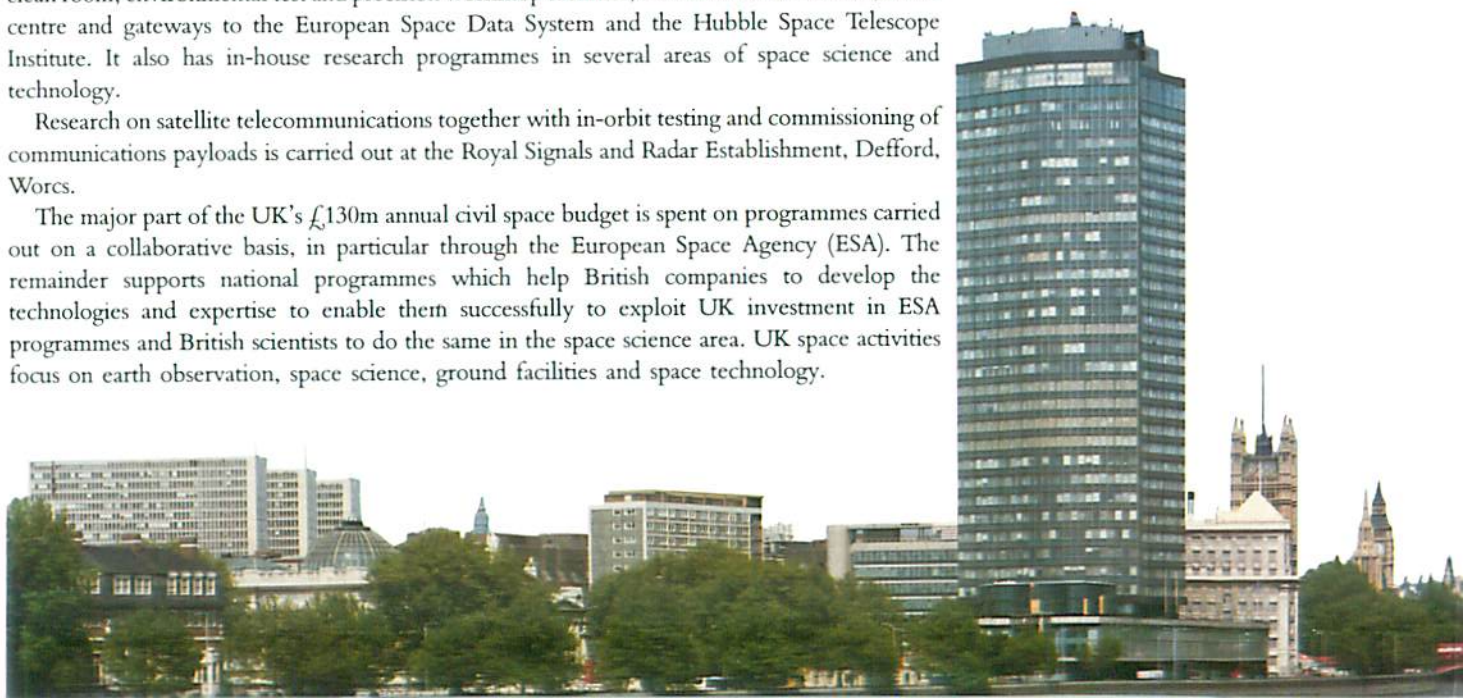
BNSC has some 235 staff operating from its London headquarters and from technical centres at the Royal Aerospace Establishment (RAE) at Farnborough, Hampshire and at the Rutherford Appleton Laboratory (RAL) at Chilton, Oxon.

RAE's Space Department carries out research and development with particular emphasis on spacecraft systems and remote sensing technology, mission analysis, orbital dynamics and ground facilities. It also runs the National Remote Sensing Centre – which advises users on commercial applications of earth observation information – and two satellite earth stations.

RAL provides and operates a number of central facilities for University groups. These include: clean room, environmental test and precision workshop facilities; a satellite control centre; a data centre and gateways to the European Space Data System and the Hubble Space Telescope Institute. It also has in-house research programmes in several areas of space science and technology.

Research on satellite telecommunications together with in-orbit testing and commissioning of communications payloads is carried out at the Royal Signals and Radar Establishment, Defford, Worcs.

The major part of the UK's £130m annual civil space budget is spent on programmes carried out on a collaborative basis, in particular through the European Space Agency (ESA). The remainder supports national programmes which help British companies to develop the technologies and expertise to enable them successfully to exploit UK investment in ESA programmes and British scientists to do the same in the space science area. UK space activities focus on earth observation, space science, ground facilities and space technology.



BNSC Millbank Tower.

Contents

Earth Observation

Earth observation is an area of space activity which is likely to yield substantial industrial, scientific and commercial benefits through the exploitation of the acquired data. It will play a key role in assisting man to make full and proper use of his environment; on the one hand to optimise finite resources, on the other maintain the integrity of the environment for future generations.

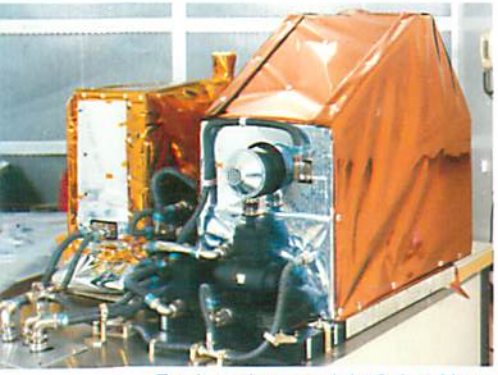
The most developed application of Earth observation is the study of atmospheric phenomena – particularly meteorology and atmospheric physics. It is difficult to define the quantitative benefits from weather satellites but they are estimated to outweigh their costs by anything from three to ten times.

Mosaic of Europe from NOAA data.

Meteorology

The first formal European meteorological satellite studies bore fruit in 1977 when METEOSAT was put into geo-stationary orbit. Long before that, however, British scientists were developing instruments, for example the infrared radiometers developed at Oxford University for measuring atmospheric temperature profiles, for experiments put into space on UK satellites.

Today two ESA METEOSATS operate as a single element in the space segment of the World Weather Watch programme, transmitting information to main World Weather Watch centres across the globe, including that located within the British Meteorological Office at Bracknell. Eumetsat (European Meteorological Satellite Organisation), with 16 European Member States, is responsible for establishing, maintaining and operating the METEOSAT operational satellite system.



Engineering model of the Along Track Scanning Radiometer for the ERS-1 satellite.

Marconi Space Systems, a major subcontractor in the Meteosat development programme, was responsible for the attitude measurement system, the attitude and orbit-control system, the imaging electronics and the communications packages of both the pre-operational satellites and the subsequent four operational craft. A sister company, Marconi Defence Systems, is currently developing a five-channel Advanced Microwave Sounding Unit (AMSU-B) for the British Meteorological Office, ready for launch on an Advanced TIROS-N Satellite in 1990. Designed to be particularly sensitive to ice clouds, and capable of sensing water vapour profiles and precipitation over land and sea, it will be Europe's first space-borne sounder operating at a frequency of 200 GHz.

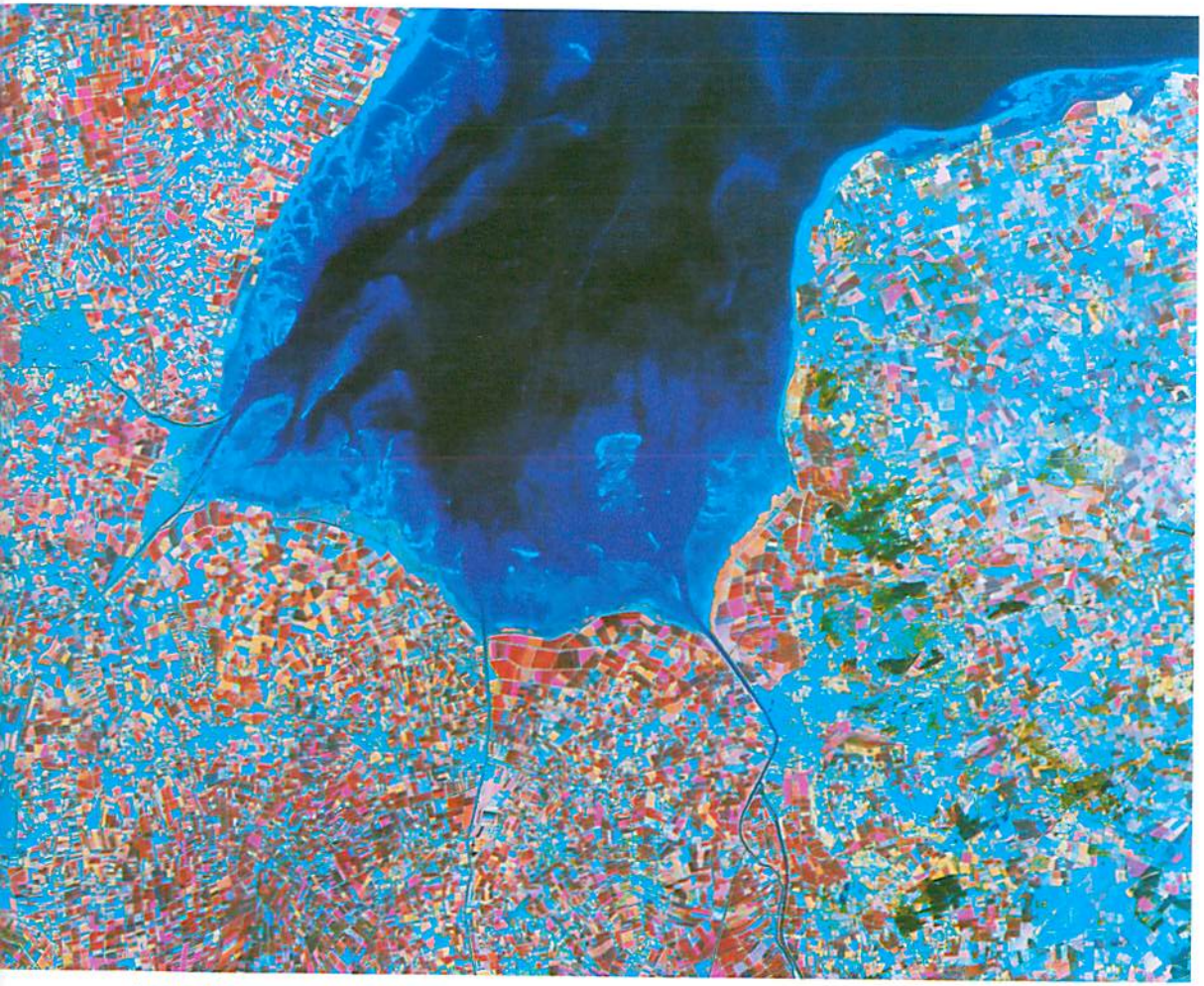
Atmospheric Sciences

Work on advanced sensors for atmospheric physics research is being undertaken in parallel with the development of meteorological satellites. Oxford University, Rutherford Appleton Laboratory and British Aerospace are developing the Improved Stratospheric and Mesospheric Sounder (ISAMS) for the US Upper Atmosphere Research Satellite (UARS). Another experiment on UARS, the Microwave Limb Sounder (MLS), involves a significant contribution from Herriot Watt University. Once launched, in 1991, UARS will provide important information on the chemistry, physics and dynamics of the atmosphere. It will contribute to our understanding of global climate change and environmental effects which are now recognised as being of vital importance for the future of mankind.

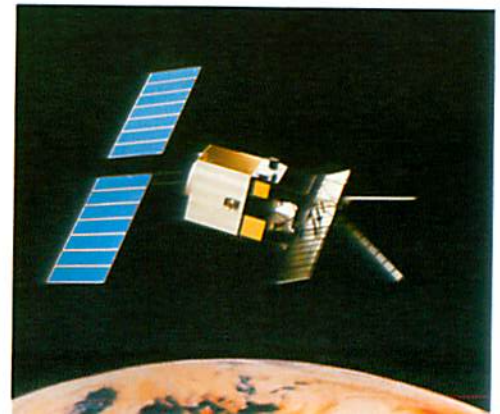
Remote Sensing of the Land, Oceans and Ice

The major part of Britain's support for remote sensing research and development is through its contribution to the European Space Agency's Earth Observation Programme, which includes ERS-1 (the first ESA remote sensing satellite) and the Columbus Programme.

Scheduled for launch in 1990, ERS-1 will provide an all-weather remote sensing facility capable of observing and monitoring the ocean, coastal zones, land and polar regions. The satellite will carry a comprehensive set of instruments, mainly microwave, including an Active Microwave Instrument (AMI) capable of



LANDSAT scene of the Wash.



Simulation of ERS-1 in orbit.

operating as a wind scatterometer, or as an imaging Synthetic Aperture Radar (SAR); a high resolution Radar Altimeter, and an Along Track Scanning Radiometer (ATSR). Britain has been involved in every aspect of the ERS-1 programme since the late 1970's with government departments helping to define programme requirements, science groups in universities supporting various research activities and industry carrying out design studies and supplying equipment. Marconi Space Systems is the major contractor for the design and manufacture of the AMI, which forms the heart of the ERS-1 payload. The ATSR is designed to measure sea surface temperature (SST) to an accuracy +0.3° Kelvin and will enable the scientific community to understand better the complex interactions between ocean, ice and atmosphere, the major driving forces for our global weather and climate system. The ATSR is designed and being built by a consortium of British institutions led by the Rutherford Appleton Laboratory, with contributions from France and Australia. Thirty-seven UK investigators representing universities, government departments and industry have been awarded Principal Investigatorships from ESA to help to promote and expand the utilisation of ERS-1 data.

The United Kingdom is a member of ESA's Columbus programme, Europe's contribution to the International Space Station. The UK's particular interest is in the polar platform element of Columbus: this will be one of the key aspects of the BNSC strategy for Earth observation. The projected launch date for the Columbus Polar Platform is 1997. British researchers and industry will have access to all elements of Columbus and will be able to make use of the wider facilities of the International Space Station. These are expected to include two US polar platforms and a Japanese polar platform which, together with the Columbus platform will provide a co-ordinated Earth observation system of unprecedented capability. Each of the platforms will carry a comprehensive payload

consisting of:

- operational meteorology instruments
- "facility" Earth observation instruments
- research instruments.

The BNSC will seek to ensure that instruments with commercial potential are included in the polar platform payloads.

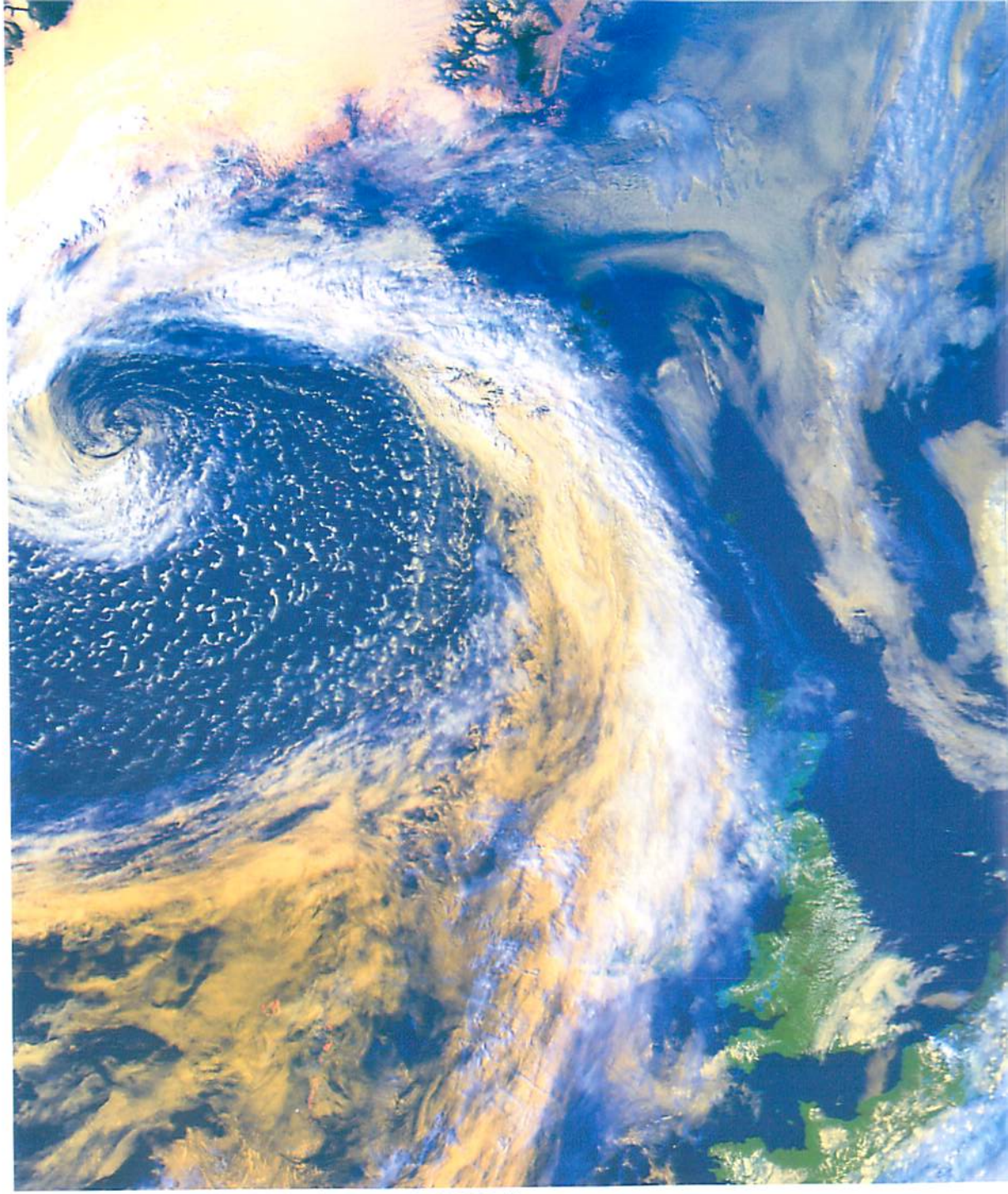
Ground Segment

Britain recognises that major benefits are to be derived through the acquisition and processing of remotely sensed data and from the information which can be extracted from such data. The BNSC is active in ensuring that potential users are made aware of the value of remotely sensed data, and of the wide range of applications for which the data can be used.

The UK's commitment to establishing the Earth Observation Data Centre (EODC) at RAE, Farnborough will help ensure that appropriate data processing, archiving and distribution strategies are developed. The EODC will play a central role in receiving data from ERS-1 on behalf of ESA. The EODC will be operated by industry, initially under contract for four years. The Centre should then be progressively taken over by the private sector.

The National Remote Sensing Centre (NRSC), which will become part of the EODC, has an extensive archive of LANDSAT and SPOT data. The NRSC provides advice and assistance to potential users and has a programme to develop applications for remotely sensed data.

ESA's Earthnet operates through a network of ground stations and is responsible for receiving and pre-processing data from in-orbit spacecraft. Earthnet distributes remotely sensed data to users via a network of National Points of Contact. The NRSC acts as the UK National Point of Contact. Earthnet has contracted the Eurimage consortium to carry out the distribution of data from LANDSATS 4 and 5.

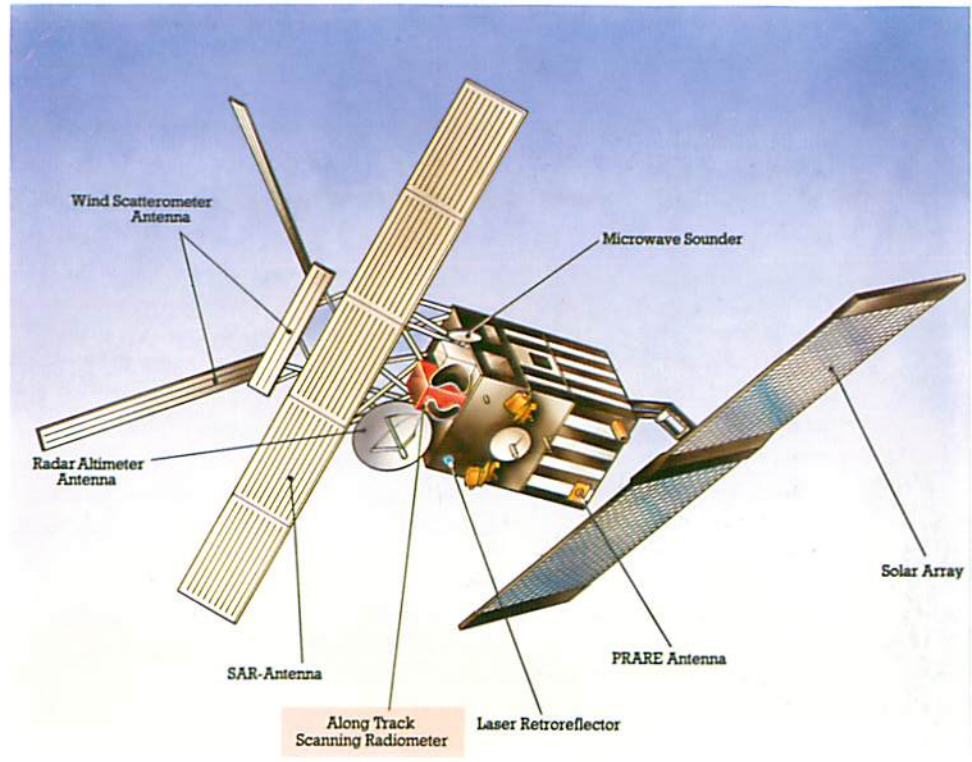


Weather pattern over North Atlantic as seen by TIROS-N.

As part of the Natural Environment Research Council's contribution to the BNSC, the Dundee Satellite Receiving Station receives data from the NOAA series of satellites for most of Western Europe. An on-line catalogue of data has been implemented and near real-time full resolution AVHRR (Advanced Very High Resolution Radiometer) data are available on floppy disks. The station has built up a unique archive of data from the NOAA satellites.

Several British companies and research organisations are able to give expert guidance and support in the areas of image processing and information extraction, and have devoloped software packages tailored for specfic applications. GEMS – the interactive image analysis system – and the SAR Data Processor are both British developments which are commercially available.

The BNSC Remote Sensing Applications Development Unit based at NERC's Monks Wood campus performs an important function in the development of applications and in fostering user awareness in the use of remotely sensed data. The unit works in partnership with research institutes, industry and government departments, and is seen as having a key role in the BNSC thrust towards deriving benefits from Earth observation activities.



ERS-1 satellite with its components identified.

Space Science

Space Science is concerned with astronomy, planetary and solar system sciences. Astronomical sources emit radiation, in varying degrees, over the whole of the electromagnetic spectrum. Only a small section of the spectrum reaches the Earth's surface because of the masking effect of the atmosphere. The ability to observe in space has therefore enabled observations to be made at entirely new wavelengths.

Major advances in the understanding of the evolution of the universe have been achieved in the last 30 years and future progress will probably be increasingly dependent on data from instruments in space. Similarly, the study and understanding of comets, planets and other objects in our solar system and, indeed, of the sun itself and its important interactions with its planets, including the Earth, are advancing rapidly.

British scientists were among the first in the world to recognise and exploit the advantages of space. Many gained international reputations and put Britain at the forefront of space research. Experienced research teams in British universities and institutes played a prominent role in several satellite missions developed over the first two decades of space exploration. Three notable examples are: the UK/US Ariel 5 X-ray astronomy mission; the US/Netherlands/UK Infrared Astronomy Mission, IRAS; and the UK/US/ESA International Ultraviolet Explorer, (IUE), which was awarded the 1988 US Presidential Award for Design Excellence.

The Infra-red Space Observatory (ISO), due for launch in 1993, will measure radiation sources in the 3 to 200 micrometre wavelength range.

The UK Science Programme

The UK Programme is pursued primarily through the European Space Agency (ESA) with subsidiary collaborative arrangements with other space powers (eg USA, USSR, and Japan) where the ESA programme does not provide timely or appropriate opportunities.

UK scientists are contributing substantially to ESA's Infra-red Space Observatory (ISO) due for launch in May 1993. ISO is designed to explore the infrared part of the electromagnetic spectrum with a sensitivity considerably higher than that which has been achieved so far. It will offer scientists sophisticated observing facilities to follow up the pioneering discoveries made by the IRAS satellite. Four instruments will allow photometric, spectroscopic and polarimetric observations to be made thereby giving insight into a very wide range of astrophysical processes.

Each of the four instruments in the observatory is being built by a consortium of institutes from different countries, and various groups in the United Kingdom are involved with the following instruments:

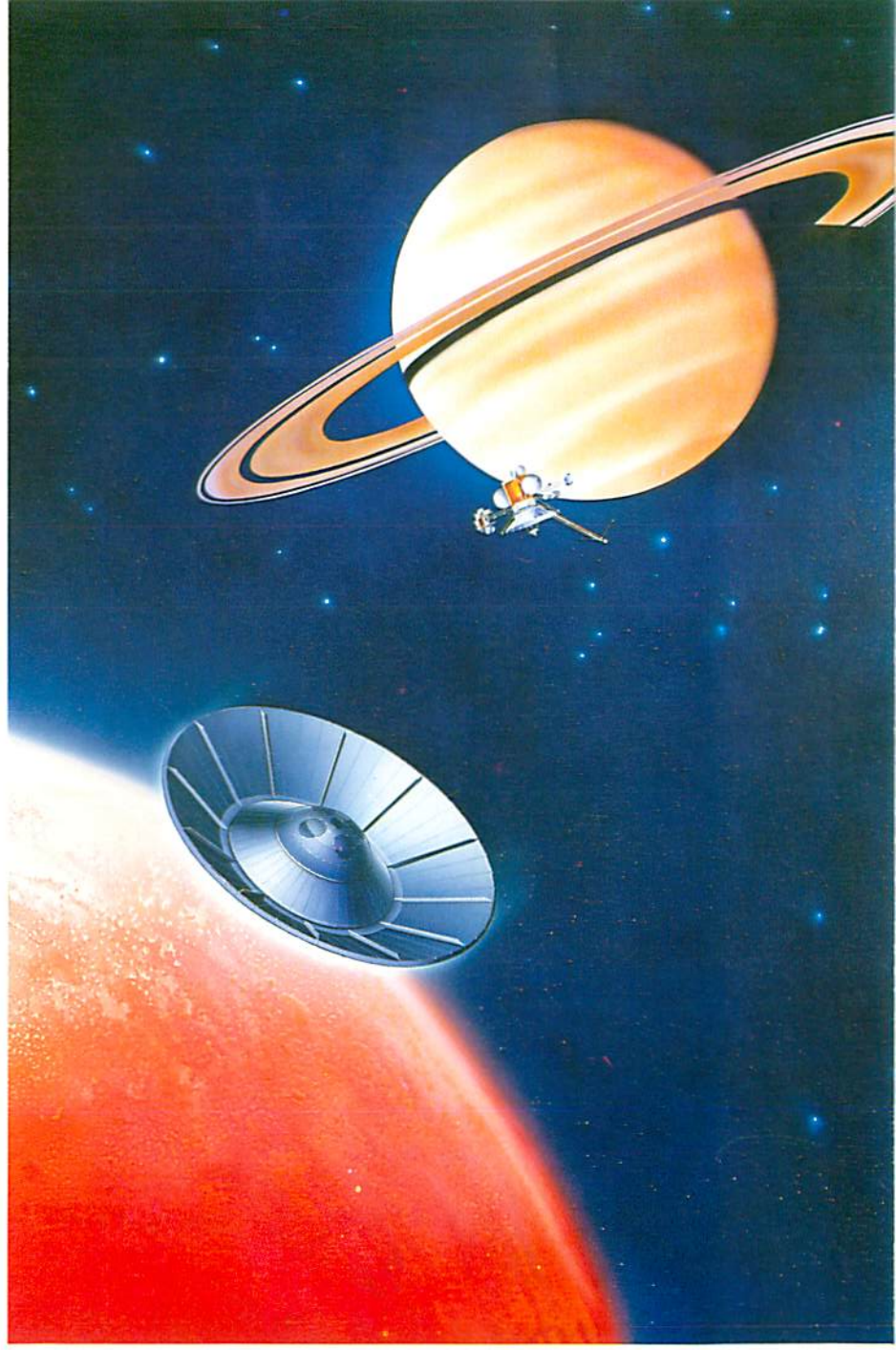
Long Wavelength Spectrometer – Queen Mary College and University College London, and RAL

Photometer – Imperial College and RAL

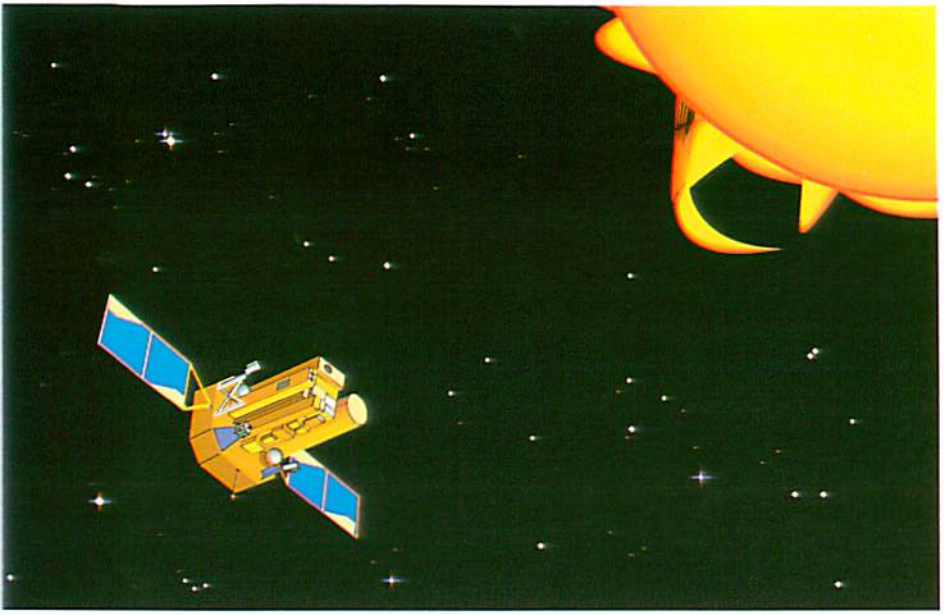
Camera – Royal Observatory Edinburgh and RAL.

Horizon 2000

In 1985 ESA agreed a long term programme of space missions up to the year 2007. The programme – Horizon 2000 – is based on four large cornerstone missions (Solar Terrestrial Science, X-ray Spectroscopy, Far Infra-red Spectroscopy and Comet Nucleus Sample Return), together with a number of medium-size missions to be chosen on a competitive



An artist's impression of the Titan probe descending to the surface of Saturn's moon, as part of the NASA/ESA Cassini-Huygens mission.



SOHO will lie between the sun and Earth monitoring solar activity and sampling the solar wind as it passes.

basis. The first of these is Cassini-Huygens, a NASA/ESA, mission to Saturn and its moon Titan.

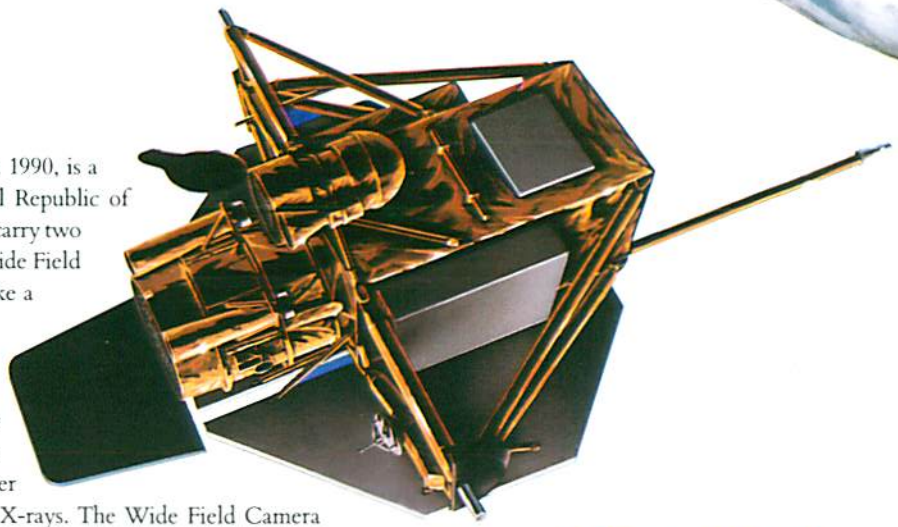
UK scientists and industry are playing an active part in Horizon 2000. UK expertise in solar terrestrial physics, developed through participation in the US/FRG/UK AMPTE mission and in the Solar Maximum Mission (SMM) will be used in the Solar Terrestrial Science Programme, which consists of two missions, SOHO and Cluster. SOHO, the Solar Heliospheric Observatory, will monitor the velocity and luminosity of the solar surface, investigate the outer layers of the Sun's atmosphere and study its coronal heating processes giving rise to the solar wind. It is planned for launch in early 1995. Cluster consists of four identical spacecraft instrumented to measure plasma particles and electromagnetic fields in the Earth's near space environment. The spacecraft will be separated by between a few hundred to a few thousand kilometres, enabling both spatial and temporal measurements to be made. They will be launched in late 1995. UK scientific groups and their collaborators have a leading role in four instruments:

On SOHO
- Coronal Diagnostic Spectrometer – University College London; the Universities of St Andrews, Oxford and Cambridge, together with the Rutherford Appleton Laboratory (RAL).

On Cluster
- Flux Gate Magnetometer – Imperial College of Science and Technology.
- Plasma Analyser – University College, London and Mullard Space Science Laboratory. Also collaborating are RAL and Queen Mary College, London.
- Digital Wave Processing – the Universities of Sheffield and Sussex, and the British Antarctic Survey.

The second cornerstone of the Horizon 2000 programme, due to be launched in 1998, is devoted to X-ray spectroscopy. Proposals for involvement in payload instruments have been made by all major UK X-ray groups and the selection will take place in mid-1989. Similarly UK planetary scientists hope to have significant involvement in Cassini-Huygens, due for launch in 1996. An Announcement of Opportunity will be issued in late 1989.

Bilateral Missions



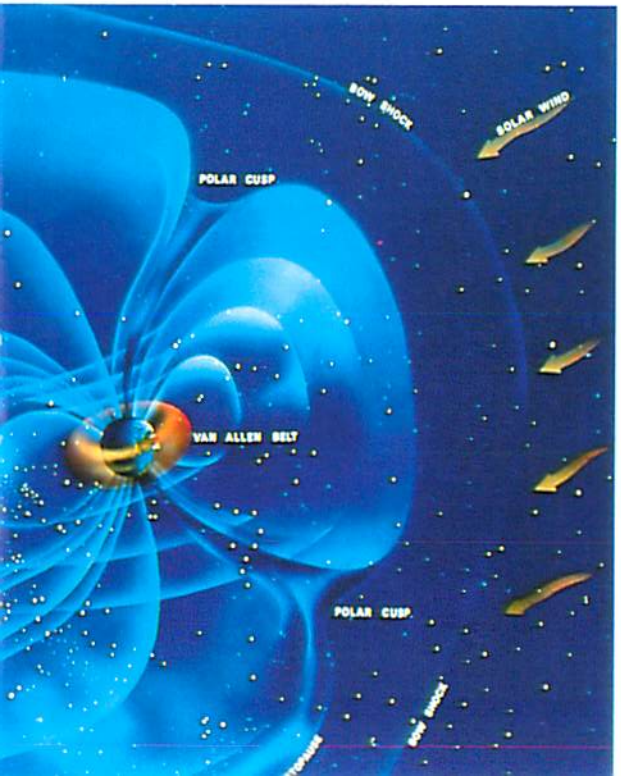
The Roentgensatellit (ROSAT), to be launched in 1990, is a collaborative X-ray mission between the Federal Republic of Germany, the UK and the USA. The satellite will carry two scientific instruments, an X-ray telescope and a Wide Field Camera. Together these instruments will undertake a systematic sky survey lasting six months followed by specific pointed observations lasting at least eighteen months. The Universities of Leicester and Birmingham, the Mullard Space Science Laboratory, Imperial College and RAL are providing the Wide Field Camera which will cover the spectral band from the far ultraviolet to soft X-rays. The Wide Field Camera consortium will be responsible or analysis of the sky survey results, with RAL and Leicester University undertaking data processing and reduction. Initially the sky survey data will only be available to those groups which provided instruments. However a sky survey catalogue will be published about one year after launch at which time data will become freely available to the international community. The BNSC has invited the whole of the UK community to bid for observing time for the pointing phase; for this activity Announcements of Opportunity will be issued at six-monthly intervals.

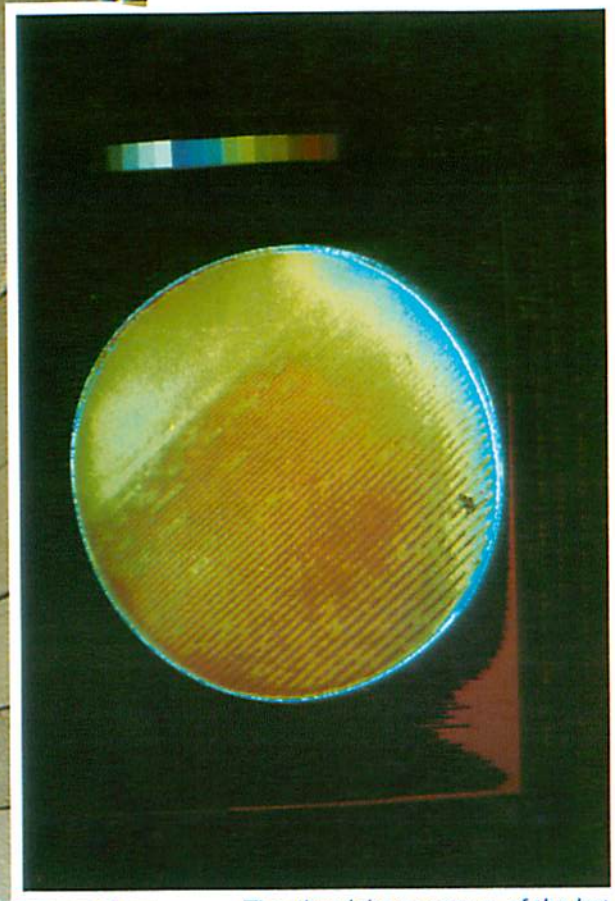
ROSAT, a joint FRG/UK/US X-ray astronomy programme satellite that will use two co-aligned telescopes to conduct the first systematic X-ray imaging survey of the complete sky.

Under the umbrella of the Agreement on Cooperation in the field of the study, exploration and use of Outer Space for Peaceful Purposes, signed between UK and USSR in March 1987, the UK was invited to participate in the USSR Spectrum-X mission – due for launch in 1993 and covering the wavelength range from the extreme ultraviolet to hard X-rays. The UK hopes to collaborate with other European countries in providing an X-ray telescope for this mission. UK groups involved are the Universities of Leicester and Birmingham, Mullard Space Science Laboratory, and RAL.

Since 1982 there has been an Aide Memoire between the SERC and the Japanese Ministry of Education, Science and Culture which includes co-operative activities in space science. Within this framework and following the successful GINGA mission, the UK has been invited to participate in the Solar-A mission which will include a suite of instruments to study high energy phenomena in solar flares. The Mullard Space Science Laboratory (MSSL) and RAL will provide a Spectrometer for this mission. Launch will be at the peak of the solar cycle in 1991 which, together with the SOHO instruments being launched close to the solar minimum in 1996, will provide a complementary and comprehensive set of solar physics data.

The four Cluster satellites will measure the solar wind in the vicinity of the Earth and its effects on the Earth's magnetic field.





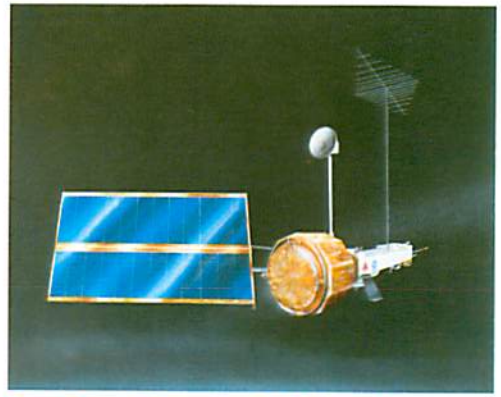
The ultraviolet spectrum of the hot supergiant star Cyngi observed by the IUE at high resolution. The spectrum (115 to 200nm) is dominated by strange blue-shifted absorbtion lines of metal formed in the expanding envelope of the star.

The UK/US/ESA International Ultraviolet Explorer (IUE), which was awarded the 1988 US Presidential Award for Design Excellence.

Space Station and Columbus

International participation in the United States' Space Station Programme was proposed in 1984. It has become a co-operative venture involving ESA, NASA, Canada and Japan. The International Space Station will be a unique, multi-use facility in low Earth orbit: a permanently manned base comprising elements provided by all the partners, called Space Station Freedom. The ESA contribution, known as the Columbus programme and including other wholly European elements, will cost £2,800m. The UK Government is providing £250m to take a 5.5% share of Columbus with UK industry leading on the Polar Platform and providing associated instrumentation and system support. Through Space Station operations it will become normal practice to build, repair, refuel and modify systems already in orbit. Satellite platforms and large antennae will be constructed in space and repaired or refuelled from S.S. Freedom, by the American space transportation system (Shuttle) or one developed by Europe. The main initial benefit will however be in the provision of international 'laboratories in space' to explore the behaviour of materials and of biological systems in the microgravity of space. Columbus will comprise three elements:

- **The Columbus Pressurised Laboratory,** which is to be permanently attached to the central core of the manned S.S. Freedom. A similar laboratory will be provided by the United States together with the living quarters and overall structure and there will also be contributions by Canada and Japan. The laboratories will be primarily for experimentation in the microgravity of space.
- **The Columbus Free-Flying Laboratory** which, once experiments and materials processing facilities have been set up within it, will fly independently away from the main space station to give long duration, undisturbed, exposure to microgravity. Subsequent modifications can be carried out by astronauts from the small European spaceplane Hermes or when the laboratory returns to the main station.
- **The Columbus Polar Platform** which is expected to be launched in 1997. This element is primarily for Earth observation and is capable of carrying and operating simultaneously many different kinds of remote sensing instruments. Design concepts are under review within ESA and British Aerospace (BAe) is expected to play a leading role in the platform's development. The overall aim is for UK firms to take a share of between 25% and 30% in this element of Columbus. Apart from BAe other major UK companies are also involved in the programme.

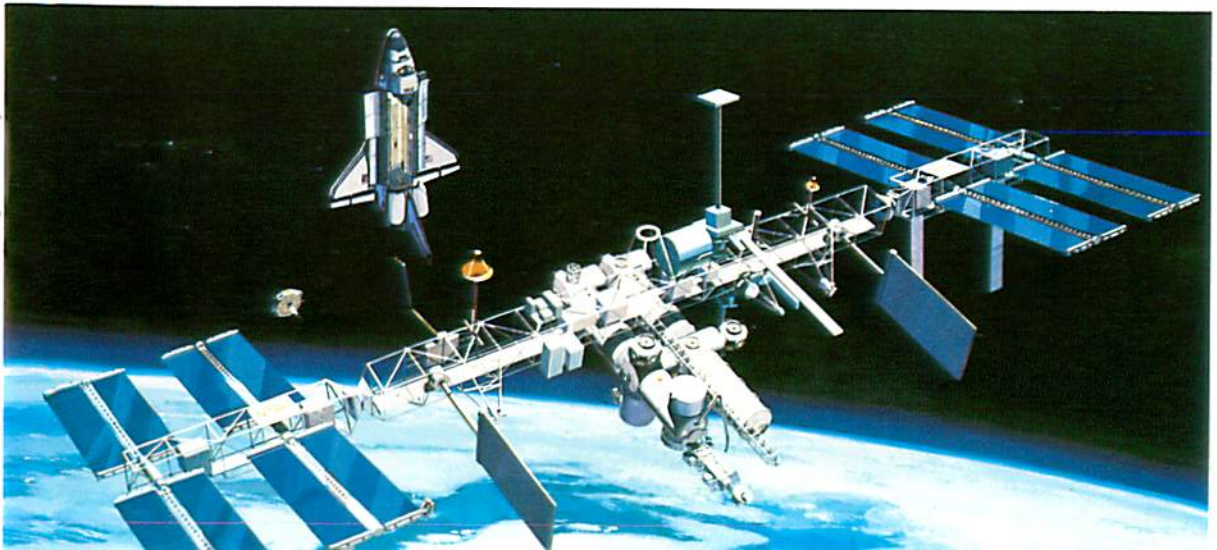


The Polar Platform, one of three elements in the Columbus programme.

The BNSC undertook a major study to determine the potential users of the International Space Station, with the objective of establishing its scientific and commercial scope. This concluded that the focus for the UK should be the polar platforms. The Centre has now moved on to assess what contributions should be made nationally to payloads and ground operations for the Columbus Polar Platform to establish the earliest commercial opportunities for Earth observation.

The Columbus Attached Laboratory and the Free Flying Laboratory will offer opportunities for exploiting the potential of very-low gravity and high-vacuum environments in work on alloys, semiconductors, optical materials and pharmaceuticals – or, indeed, on the physiology of man himself.

In the longer term the UK may participate in the ESA Microgravity Programme if opportunities arise which might lead to economic or direct commercial benefit.



The International Space Station which will be launched in the late 1990s.

Space Technology and Ground Facilities

Aerial 4 at Goonhilly Downs.

In space technology, BNSC aims to meet the technical requirements and priorities of the UK's space science and applications programmes.

BNSC carries out a number of space technology programmes through the Ministry of Defence (MOD) and the Science and Engineering Research Council (SERC).

MOD's Royal Aerospace Establishment (RAE) at Farnborough and its Royal Signals and Radar Establishment (RSRE) at Defford carry out extensive research intra-murally and through industry into spacecraft technology, civil satellite communications, remote sensing and new space concepts. A wide range of environmental test facilities, including large thermal vacuum chambers and vibration testing equipment, is sited at RAE.

SERC's Rutherford Appleton Laboratory has a vigorous programme of space technology developments both in-house and through universities to underpin the space research programmes of the academic, scientific and engineering communities.

RAL's special facilities comprise clean room, environmental test and precision workshop facilities, a satellite control centre (for tracking, data reception and control); a data centre with Starlink astronomical network, geophysical data facility, Satellite Data Centre archive and World Data Centre; and gateways to the European Space Data System and the Hubble Space Telescope Institute.

Ground facilities are also vital to the development of the space programme, not only for operations but for exploitation of the acquired data. Operations facilities are situated at RAE's Lasham ground station and RAL's Chilton site.

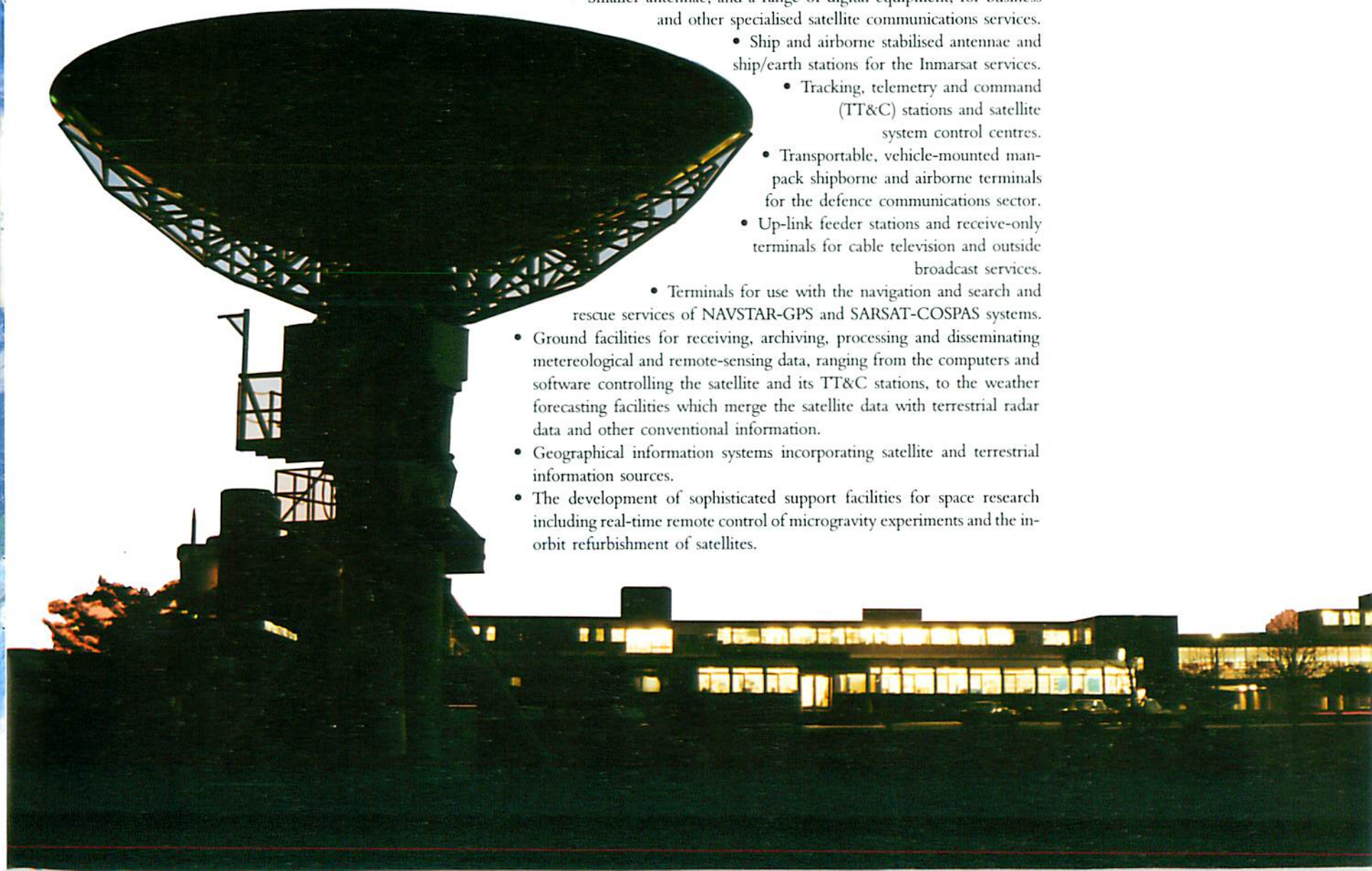
In satellite communications BNSC obtains the maximum benefit from RSRE's Satellite Communications Centre, which is the best of its kind in

12m satellite tracking antenna at RAL.

The Ferranti designed and manufactured Earth terminal for experimental programmes with Ku band satellites and OLYMPUS.

Europe. It has a range of terminals covering various frequency bands with full supporting services. RSRE is currently establishing a base terminal to support trials of the Olympus communications satellite following its 1989 launch. British industry's contributions in this sector include:

- Large standard Earth stations with 13-30m diameter antennae for trunk telephony and TV distribution in the Intelsat, Eutelsat and Inmarsat systems – for example, those provided for the new British Telecom 'space port' in London's docklands.
- Smaller antennae, and a range of digital equipment, for business and other specialised satellite communications services.
- Ship and airborne stabilised antennae and ship/earth stations for the Inmarsat services.
- Tracking, telemetry and command (TT&C) stations and satellite system control centres.
- Transportable, vehicle-mounted man-pack shipborne and airborne terminals for the defence communications sector.
- Up-link feeder stations and receive-only terminals for cable television and outside broadcast services.
- Terminals for use with the navigation and search and rescue services of NAVSTAR-GPS and SARSAT-COSPAS systems.
- Ground facilities for receiving, archiving, processing and disseminating metereological and remote-sensing data, ranging from the computers and software controlling the satellite and its TT&C stations, to the weather forecasting facilities which merge the satellite data with terrestrial radar data and other conventional information.
- Geographical information systems incorporating satellite and terrestrial information sources.
- The development of sophisticated support facilities for space research including real-time remote control of microgravity experiments and the in-orbit refurbishment of satellites.



Satellite Communications

Britain has maintained its early lead in satellite communications in Europe, starting with the OTS (Orbital Test Satellite), the first operational European civil communications satellite, and SKYNET 2, the world's longest-operating military communication satellite. British Aerospace (BAe) has been a prime contractor for all the European Space Agency's (ESA) communications satellites and Marconi Space Systems has built many internationally competitive payloads.

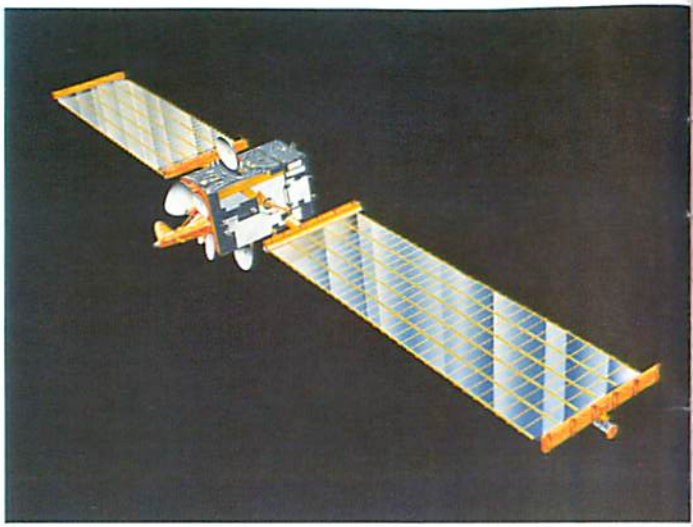
In the past, concentrating on this area of greatest commercial promise enabled the UK to build up one of the strongest communications satellite industries outside the USA. Britain has successfully competed internationally to supply satellites for the International Maritime Satellite Organisation (Inmarsat) and NATO 4 and is a sub-contractor for the INTELSAT 6 series of satellites. Now that the market is established, decisions on future satellite communications projects will be made increasingly on a commercial basis by companies rather than by the Government.

The UK is not only a strong developer of communications satellites in Europe, but also a major user, with more satellite use than any other European country.

Notwithstanding the continued advances in terrestrial communications technology, satellites will remain important in the world's telecommunications systems, particularly for mobile users for which cables and other forms of transmission are either impractical or expensive. Within the United Kingdom a major part of communications satellite funding has been directed towards mobile applications, initially in the marine area and most recently in aeronautical communications. In the future, the applications will be extended towards land mobiles, eg trucks and smaller craft, but companies such as STC, Ferranti, and Racal have already gained invaluable experience. These applications and others, where links are needed speedily, or for broadcasting, are the most rapidly expanding markets.

Sixty-three British experimenters, ranging from language schools to teaching hospitals are looking forward to the launch of ESA's OLYMPUS-1 satellite in 1989. It will be one of the largest communications satellites ever built and is another for which British Aerospace is the prime contractor. The groups will use OLYMPUS to carry out many experiments and demonstrations of new services. One example is distance learning. Users will be able to undertake studies, on a Europe-wide basis, at a time and place of their choosing, since the material beamed by satellite can be down-loaded to video recorders during the day or night and used at convenient times.

The OLYMPUS multi-purpose communications satellite in the British Aerospace satellite assembly hall at Stevenage.



OLYMPUS, the largest ever communications satellite.

TDS4 earth terminal: to support OLYMPUS specialised services payload utilisation.

TDS6 earth terminal: to support OLYMPUS 20/30 GHz utilisation.

Space Launch Systems

Satellite launch systems have evolved into two forms, expendable and recoverable. Britain had early experience in the design and development of expendable launching systems starting with the Skylark series of sounding rockets for space research in the 1950s. These are still being made and flown today. This was followed by Blue Streak, Black Knight, and Black Arrow, the launch vehicle which placed the UK's PROSPERO technology satellite in orbit in 1971.

European launcher capability is now maintained in the European Space Agency's Ariane programme, to which the UK will have continued access. The Ferranti inertial platforms have always been at the heart of the launcher's guidance system and have given Ariane an unrivalled reputation for accuracy of placing payloads into orbit. British Aerospace, using its experience with large carbon fibre structures, has developed a facility – the SPELDA – which allows two satellites to be injected into orbit from a single launch of Ariane IV.

The USA developed the first recoverable launch system – the Space Transportation System (STS), commonly known as the Space Shuttle.

Europe contributed to the STS programme with the European Space Agency's development of Spacelab – a pressurised laboratory designed to fit into the Shuttle bay and accommodate astronauts in a 'shirt sleeve environment', and 'pallets' (open instrument platforms) developed by British Aerospace to fly on the Shuttle with experiments to be exposed to space conditions.

British Aerospace and Rolls Royce are continuing research into the revolutionary British space plane concept – Hotol. BNSC is continuing to support any efforts the companies make to achieve international collaboration on this.

Ariane IV being launched at Kourou.

BNSC Headquarters

BNSC, Millbank Tower, Millbank, London SW1P 4QU
Tel (Information Office) 01-217 4290 or 4289. (Switchboard) 01-217 3000
Telex 8811074 Fax 01-821 5387

BNSC Technology Centres

Space Department, Royal Aerospace Establishment, Farnborough, Hampshire GU14 6TD.
Tel (Switchboard) 0252 24461 Telex 858134 Fax 0252 522959

BNSC National Remote Sensing Centre, Royal Aerospace Establishment, Farnborough, Hampshire GU14 6TD. Tel (Switchboard) 0252 541464 Telex 858442 Fax 0252 515518

SERC Space Science Department, Rutherford Appleton Laboratory, Chilton, Didcot, Oxon OX11 0QX. Tel 0235 21900 Extn. 5572 Telex 83159 (RUTHLE G) Fax 0235 445848

Royal Signals and Radar Establishment, Defford, Worcestershire WR8 9DD
Tel 0386 750376 Telex 335632 Fax 0386 750376 Extn. 321

BNSC Remote Sensing Applications Development Unit, Monks Wood Experimental Station, Abbots Ripton, Huntingdon, Cambs PE17 2LS.
Tel 04873 381 Telex 32416 MONITE Fax 04873 467

Other useful addresses

United Kingdom Industrial Space Committee, c/o Mr M Tibby, 29 King Street, St James's, London SW1Y 6RD

British Association of Remote Sensing Companies, PO Box 235, Uxbridge, Middlesex UB8 3UX

Other Publications

Available from BNSC
Information pack containing fact sheets on areas of UK space activity
The Earth Below: A look at Satellite Remote Sensing
Space Research at the Rutherford Appleton Laboratory
University and Polytechnic Expertise in Space
Remote Sensing: Education and Training Opportunities
National Remote Sensing Centre
'Britain in Space' posters
BNSC Quarterly Newsletter

Copies of these publications may be obtained (free of charge) from BNSC at the address above or telephone 01-217 4305.

BNSC

Available from HMSO Bookshops or Telephone 01-873 0011:
Directory of UK Space Capabilities 1988 (ISBN 0 11 514639 3 - £25.00)
Space Science and Technology: Directory of courses, research opportunities and sponsorship for students at UK universities and colleges. (ISBN 0 11 514672 5 – £9.50).